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In vitro study of bactericidal and fungicidal effects of coriander seed, fennel, and spike lavender essential oils

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Abstract. Due to the limited use of antibiotics in agriculture, scientists are looking for alternative means to increase productivity and prevent infectious diseases. Vegetable essential oils are a promising replacement for antibiotics and growth stimulants. Essential oils are natural bioactive substances obtained from plants that have antioxidant, antimicrobial and anti-inflammatory effects on the macroorganism. They do not accumulate in the body of animals, have minimal side effects, and are characterized by the absence of resistance development in pathogenic microorganisms. Despite the long experience of using essential oils, there is currently insufficient detailed information about the effectiveness and mechanisms of their action in practical conditions. Thus, the purpose of this study was to study the antibacterial and antifungal effects of essential oils obtained from various plant sources, such as coriander (Coriandrum sativum), fennel (Foeniculum vulgare Mill), and spike lavender (Lavandula angustifolia). A comparative analysis of the antibacterial effects of essential oils on the tested strains showed a variety of their effects. The most pronounced antibacterial activity was demonstrated by seed coriander essential oil, especially against strains Morganella morganii EB 17, Listeria monocytogenes, Salmonella enteritidis, Saccharomyces cerevisiae, and Candida albicans. A significant effect was also recorded in all the studied essential oils against Candida albicans fungi and the pathogenic microorganism Listeria monocytogenes.

1 Introduction

Growing concern about the use of antibiotics as growth promoters in farm animal feed has led to the ban of feed antibiotics by European Union (Regulation (EU) No 1831/2003). It is assumed that this ban will lead to a decrease in the productivity of farm animals, as well as to an increase in the frequency of diseases of the gastrointestinal tract due to increased

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proliferation of intestinal pathogens [1]. In this regard, the work of scientists is aimed at finding the best alternatives that can provide a similar effect and productivity without causing negative consequences.

One of these substances are various essential oils that play an important role in maintaining normal physiological functions and animal health, as well as in protecting animals from infectious diseases [2]. Essential oils are complex mixtures of volatile compounds that are present in various parts of aromatic plants. The main components of essential oils are terpenes; aldehydes, alcohols and esters are also present as secondary components [3].

Essential oils have a wide range of biological effects, depending on their constituent components and extraction methods from plants. It has been shown that essential oils, as well as some of their individual components, have antimicrobial, antiviral, antibiotic, anti-inflammatory, and antioxidant properties, as well as effects on the nervous system, including anti-stress effects [4]. Essential oils, depending on their composition, may have bacteriostatic or bactericidal effects on different types of bacteria, depending on the cell wall structure (gram-positive and gram-negative). The mechanism of antibacterial action is provided by a sequence of biochemical reactions inside the bacterial cell, which depend on the type of chemical components present in the essential oil. Since these compounds are lipophilic, essential oils easily penetrate the cell membranes of bacteria and disrupt critical processes of the cell membrane, such as nutrient processing, synthesis of structural molecules, release of growth regulators, and affect the cell energy processes [5]. In addition to their effect on microbial cells, essential oils and their components exhibit antifungal activity in relation to cell viability, mycelium growth and the ability of mold fungi to produce mycotoxins [6].

One of the most cultivated crops in the Russian Federation, which occupies up to 90% of the acreage occupied by ether-bearing plants, is coriander (*Coriandrum sativum*) [7,8]. The main active ingredient of coriander fruit essential oil is linalool (about 70%). It is known to exhibit antimicrobial, anti-inflammatory, anti-cancer, and antioxidant properties [9]. The effectiveness of linalool has been established in model animals: its antihyperalgesic and antinociceptive effects have been shown. Thus, coriander fruit essential oil has great potential as a natural and safe alternative to antimicrobial therapeutics [10,11].

Fennel (*Foeniculum vulgare Mill)* is a crop close to coriander. The main component (about 70%) contained in its essential oil is anethol, which has powerful anti-inflammatory and neuroprotective properties. A number of experiments conducted on laboratory animals revealed that the main active ingredient of fennel essential oil in the treatment of chronic structural injury eliminates damage to the sciatic nerve, increasing its conductivity [12]. It was found that trans-anethol is able to affect bacterial communication with its subsequent disruption, which makes it possible to recommend essential oil from fennel fruits as an alternative to antimicrobial agents to combat *R. Aegidinosa* and other clinically significant pathogenic microorganisms [13].

Spiked lavender *Lavandula angustifolia* is widespread in many countries of the European Union, in Canada, the USA, Moldova, Russia, in particular in the Republic of Crimea. The composition of the essential oil from the inflorescences of spiked lavender mainly includes linalyl acetate (up to 25-47%), linalool (20-45%), lavandulyl acetate (0-8%), lavandulol (0-3%). These components are considered the most valuable, providing a characteristic floral lavender aroma and pharmacological properties. Lavender essential oil has sedative, anticonvulsive, analgesic, antiseptic, and antioxidant effects [11]. It is especially effective in the treatment of inflammatory diseases of the kidneys and urinary tract. Lavender essential oil is an official medicinal product in the USA, France, Italy, Great Britain, Germany, and India. It is a part of a number of medicines [14, 15].

2 Materials and Methods

The study was carried out by the disco-diffusion method according to the MUC.4.2.1890-04[16]. For the study, overnight cultures of *Klebsiella ssp*, *Morganella morganii ssp, Listeria monocytogenes, Pseudomonas aeruginosa ssp*, *E. coli* 113-3, *E. coli* K-12, *Streptococcus pyogenes*, *Klebsiella pneumoniae ssp*, *Salmonella enteritidis, Saccharomyces cerevisiae, Candida albicans)* grown on mown Muller-Hinton and Saburo agar at temperatures of 37 and 27°C. Cultures were washed off the agar with sterile saline solution and adjusted to a density of 0.5 according to the McFarland turbidity standard, CFU of yeast and fungi in 1 ml of suspension was determined in the Goryaev counting chamber. 1 ml of microbial suspension was applied to the surface of Petri dishes with 20 ml of Saburo agar for fungi and Muller-Hinton for bacteria. Discs of filter paper impregnated with the studied essential oils were laid out on the surface of the seeded cup with sterile tweezers. The amount of oil on the disc was 20 µl. For comparison, standard discs with antibiotics were placed on the surface of the seeded cup: tetracycline, cefazolin, kanamycin, polymyxin, gentamicin, ampicillin (Research Center for Pharmacotherapy). The cups were incubated in a thermostat for 24 hours at a temperature of 37°C, with fungi - at a temperature of 27°C. Sterile water was used as a negative control. All studies were conducted in three repetitions. A caliper was used to measure the growth inhibition zone around discs with essential oils and antibiotics with an accuracy of up to a millimeter in reflected light. Statistical analysis was performed using the Statistica program.

3 Results and Discussion

When comparing the inhibitory effect of the studied essential oils, it was revealed that they have a different effect on the growth of test crops, depending on oil type (Table 1).

Table 1. Microbial growth retardation zones, mm.

Culture	Tetracycline 30 µg	Cefazolin 30 µg	Ampicillin 10 µg	Gentamicin 10 µg	Polymyxin 300 U	Kanamycin 30 µg	Fennel 20 µl	Coriander 20 µl	Lavender 20 µl
Klebsiella spp	12	12	0	14	12	8	2	5	5
Morganella morganii spp	18	0	8	15	10	14	9	22	10
Pseudomonas aeruginosa spp	0	13	12	10	8	8	3	9	7
E.coli 113-3	12	12	10	12	10	14	2	2	4
Streptococcus pyogenes spp	19	14	21	18	14	22	2	7	8
Klebsiella pneumonia spp	0	6	2	12	12	10	2	2	5
E.coli K-12	12	10	12	12	8	15	2	2	5
Listeria monocytogenes spp	0	26	27	24	0	0	28	32	26

Saccharomyces cerevisiae	0	0	0	0	0	0	10	30	12
Candida albicans	0	0	0	0	0	0	25	38	21
Salmonella enteritidis spp	23	33	22	23	20	21	9	20	8

The most pronounced antibacterial activity was noted in the essential oil of coriander seed, especially in relation to strains *Morganella morganii* EB 17, *Listeria monocytogenes*, *Salmonella enteritidis*, *Saccharomyces cerevisiae, Candida albicans*, where the growth retardation zone was at the level of the antibiotics used or even exceeded them. Fungi *Candida albicans, Saccharomyces cerevisiae*, as well as the bacterium *Listeria monocytogenes* showed high sensitivity to all oils (Fig. 1).

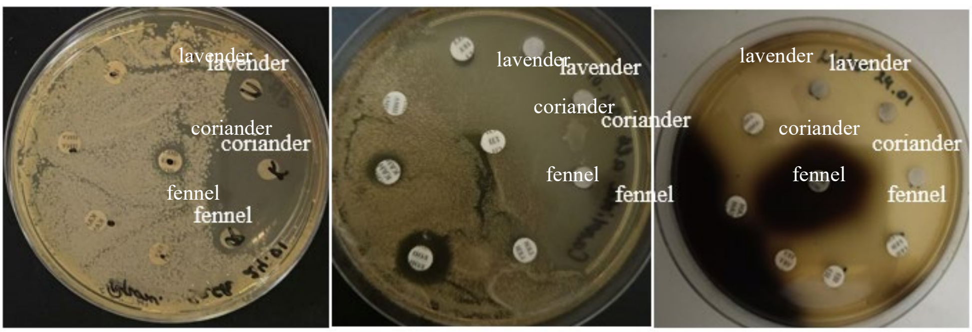

Fig. 1. Growth retardation zones of *Saccharomyces cerevisiae, Candida albicans* and *Listeria monocytogenes spp cultures* (from left to right).

Essential oils of common fennel and narrow-leaved lavender showed a pronounced effect against strains of *Morganella morganii ssp*, *Pseudomonas aeruginosa ssp, Listeria monocytogenes.* In relation to other strains of fennel and lavender EO had the least pronounced effect.

4 Conclusion

In the context of organic farming, limiting the use of feed antibiotics and limiting the use of antibiotics for therapeutic purposes, scientists are looking for alternative solutions to increase the productivity of farm animals and prevent diseases. In this regard, substances of plant origin, such as essential oils, have attracted special attention of researchers, since they are environmentally safe and effective alternatives to feed antibiotics. Coriander and fennel are inexpensive and easily accessible crops, with high oil yield and have extensive biological properties. Although the analyzed essential oils showed a similar pronounced fungicidal effect against unicellular fungi of the genera *Candida albicans* and *Saccharomyces cerevisiae,* their inhibitory effect on bacterial growth was manifested to varying degrees depending on the type of oil and the taxonomic affiliation of the microorganism. Therefore, this requires further in-depth study not only in vitro, but also on live models. The bactericidal and fungicidal action of essential oils in relation to conditionally pathogenic microorganisms will allow them to be used in the diets of farm animals to prevent infectious diseases and increase productivity as an alternative to feed antibiotics, which will allow obtaining organic environmentally safe products and increase the profitability of various branches of agricultural production.

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